# NORTH-EAST ASIAN TERRANES AND PERMIAN PALAEOGEOGRAPHY IN INNER MONGOLIA, CHINA

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SHAO JI'AN & ZHAN LIPEI, 1998:11:30. North-east Asian terranes and Permian palaeogeography in Inner Mongolia, China. *Proceedings of the Royal Society of Victoria* 110(1/2): 317–321. ISSN 0035-9211.

This work discusses, in view of terrane tectonics, why the Tethyan and Gondwana–Tethyan fossils appear in North-east Asia and demonstrates that the Inner-Mongolian epicontinental sea was not connected with Yanbian–Sikhote area in the Permian.

THE TETHYS is a nearly E–W stretching ancient ocean between the Gondwanaland and Laurasia. It was consumed in the Late Permian–Early Triassic. However, fossils of the Tethys and even the Gondwana–Tethys have been found frequently in the Yanji area of Jilin Province and the Nadanhada of east Heilongjiang Province in North-east China, as well as in the Far East of Russia, accompanied by a suit of residual segments of palaeo-seamount and ophiolite, which can be divided, through our work, into two types, one of which is represented by the Yanji-Khanka–South Primorye Terrane containing the Gondwana-affinity, or the Gondwana–Tethyan, fossils. These fossils are preserved in gravels or blocks of olistostrom; they usually coexist with Cordilleran-type ophiolite residues (Shao et al. 1995a; Zhang 1990). The other is represented by the Nadanhada Terrane containing Tethyan fauna fossils. These fossils are preserved in limestones. The limestones and associated basalts are seamount residues (Mizutani et al. 1990; Shao et al. 1991). The basalts are rich in alkaline and Ti, mainly picrite, and with features of ocean island basalts. There are also seamount type mafic–ultramafic rocks, used to be referred to as Raohe ophiolite, rich in Fe, Ti and light rare earth elements.

Mixed assemblages of warm-water and cool-water faunas in the Yanji area can be compared with those in Tibet and West Yunnan (Baoshan area) of China, as well as Russia and Japan (Tazawa 1991; Zhan & Shao 1993) (Table 1). The Early Permian fusulinids, corals and brachiopods are comparable with those in Tibet in their faunal features, evolution, and mixing of warm-water and cool-water faunas. The mixed faunas include warm-water fusulinid *Parafusulina*, *Pseudofusulina*, associated with cool-water *Monodiexodina*, Cathaysian-Tethys brachiopods *Haydenella*, *Spinomarginifera*, *Urushtenoidea* and *Transennatia* mixed with cool-water brachiopods *Yakovlevia*, *Liosotella*, *Costiferina*, *Marginifera* cf. *himalayensis*, *Neospirifer* and *Spiriferella*. Similarly, the Yanji faunas are comparable with those in South Primorye of Russia and Kitakami Mountains of Japan. A set of fusulinids and corals belonging to the warm-water type ($C_3$–$P_t$) are found in Nadanhada, with typical features of the Cathaysian–Tethys faunas and evolutionary tendency roughly similar to that of the Southern-Guizhou faunas of South China (Table 2), Bikin of Russia, Mino of Japan, Taiwan and Fujian of China.

On the existence of the Tethyan faunas in north-east Asia, different explanations have been put forward by previous researchers. Huang & Chen (1987) referred to it as the Mongolian–Sikhote Tethys; Sheng & Wang (1981) called it Angara Tethys, explaining the mixing of cool and warm water faunas with the northward warm current (Tazawa 1991; Tang et al. 1992; Shi & Zhan 1995).

We explain it in terms of terrane, considering the Tethyan residues found now on the high latitudes in north-east Asia as being originally formed on the low latitudes in the eastward extended part of the Tethyan Ocean in the Permian. At this time, the spreading ridge is E–W, roughly parallel with the main consuming zone on its north side. The Tethyan Ocean is then cut up into segments and successively transported northward by activities of a series of transform faults. The segments sticking onto the eastern margin of the Asian continent are later pushed further onto the high latitudes by the continental margin strike-slip fault system (Shao 1998) (Fig. 1). This argument has been proved with the biogeographical and palaeomagnetic data of the Nadanhada terrane. Study on the conodonts shows that the terrane was still in the warm-water Tethys domain at latitude less than 30°N in Late Triassic (Wang et al. 1986)

| | | Y | T | R | J | | | Y | T | R | J |
|---|---|---|---|---|---|---|---|---|---|---|---|
| F | *Parafusulina* | × | × | × | | B | *Leptodus* | × | × | × | × |
| | *Schwagerina* | × | × | | × | | *Geyerella* | × | | | × |
| | *Pseudofusulina* | × | × | × | | | *Meekella* | × | | × | × |
| | *Chusenella* | × | × | × | | | *Spinomarginifera* | × | × | × | |
| | *Neoschwagerina* | × | × | × | | | *Urushtenoidea* | × | | | × |
| | *Yabeina* | × | × | × | | | *Permundaria* | × | | | × |
| | *Neomisellina* | × | × | × | | | *Permianella* | | | | × |
| | *Sumatrina* | × | × | | | | *Haydenella* | × | × | × | |
| | *Lepidolina* | × | | × | × | | *Transennatia* | × | × | × | × |
| | *Monodiexodina* | × | × | × | × | | *Tyloplecta* | × | | × | × |
| | *Verbeekina* | × | × | | | | *Derbyia* | × | × | × | × |
| | *Codonofusiella* | × | × | × | | | *Waagenoconcha* | × | × | × | × |
| | *Pseudodoliolina* | × | × | × | | | *Anidanthus* | × | × | × | × |
| | *Reichelina* | | × | × | | | *Stenoscisma* | × | × | × | × |
| | *Rauserella* | × | | × | | | *Spiriferella* | × | × | × | × |
| | *Kahlerina* | × | × | × | | | *Neospirifer* | × | × | | × |
| C | *Szechuanophyllum* | | × | | | | *Yakovlevia* | × | | | |
| | *Yatsengia* | × | | | × | | *Muirwoodia* | × | | | × |
| | *Wetzelella* | | × | × | × | | *Costiferina* | × | × | | |
| | *Wentzelloides* | | × | | × | | *Lamnimargus* | × | × | × | |
| | *Waangenophyllum* | | × | | | | *Kiangsiella* | | | × | |
| | *Lytvolasma* | | × | | | | *Edriasteges* | | | × | × |
| | *Cyathocarinia* | | × | | | | *Strophalosiina* | | × | × | |
| | *Polythecalis* | | × | × | | | *Squamularia* | | | × | |
| | | | | | | A | *Timorites* | | × | × | |
| | | | | | | | *Xenodiscus* | | | × | |
| | | | | | | | *Cyclolobus* | | × | × | |

*Table 1.* Correlation chart of Permian fossils in Yanji, Tibet, Russia (South Primorye) and Japan (Kitakami). Y, Yanji, China; T, Tibet, China; R, Russia; J, Japan. F, Fusulinida; C, coral; B, Brachiopoda; A, ammonites.

| | | South Guizhou in South China | Nadanhada in North-east China |
|---|---|---|---|
| $P_2$ | Wujiapingian | *Codonofusiella-Reichelina* Zone | |
| $P_1$ | Maokouan | *Yabeina-Neomisellina* Zone | |
| | | *Neoschwagerina* Zone | *Neoschwagerina* Zone |
| | | *Cancellina-Parafusulina* Zone | |
| | Qixian | *Misellina-Brevaxina* Zone | *Misellina* Zone |
| | Longyinian | *Pamirina-Chalaroshwagerina* Zone | *Chalaroschwagerina* Zone |
| | | *Sphaeroschwagerina glomerose* Zone | |
| $C_2$ | Mapingian | *Pseudoschwagerina* Zone | *Pseudoschwagerina* Zone |
| | | *Triticites* Zone | *Triticites* Zone |
| | | *Montiparus* Zone | |

*Table 2.* Comparison of Palaeozoic fossil assemblage zones in Nadanhada and southern Guizhou, China.

and the radiolarian fossils show that it arrived at the deep cool water environment after Jurassic (Zhang 1992). Our palaeomagnetic data (Shao et al. 1995b) indicate the following sequence of the positions of the terrane: $C_3$—19.4°S, $P_1$—10.3°S, $T_3$—12.2°N, $K_1$—33.6°N (Fig. 1). In

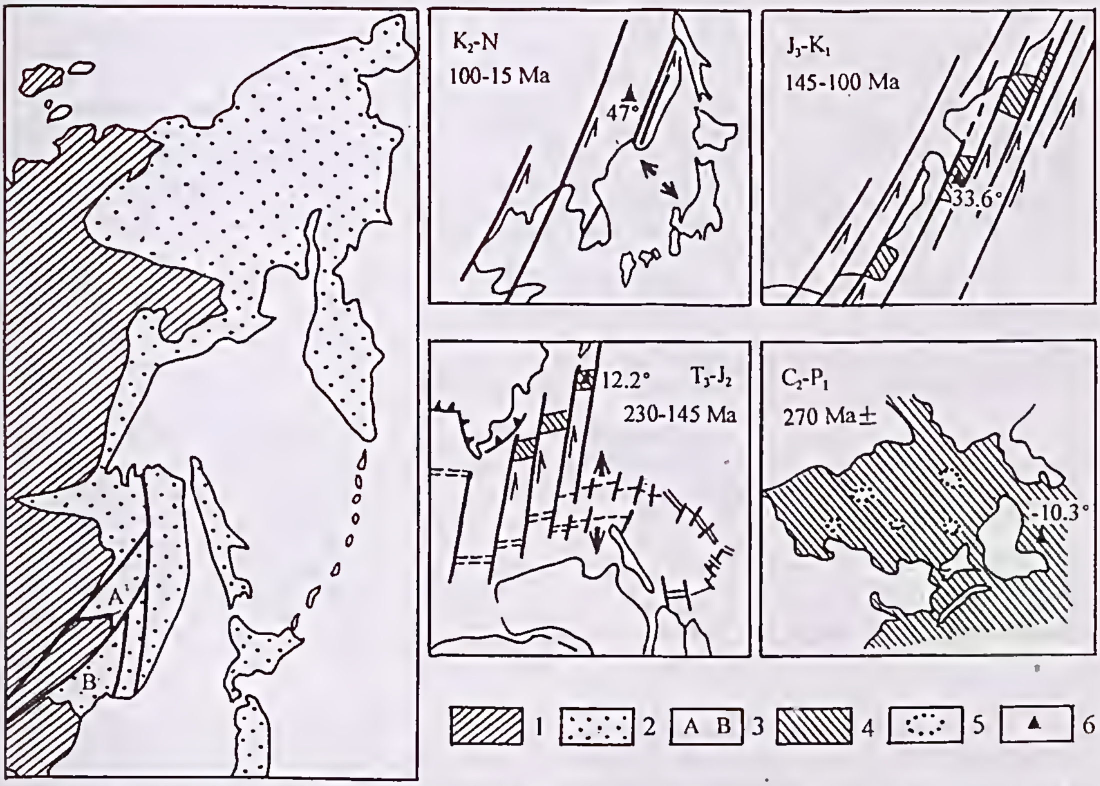


*Fig. 1.* The Mesozoic North-east Asian continental margin and its evolutionary history. 1. Mesozoic Asian continent. 2. Accretional margin of the Mesozoic Asian continent. 3. A, Nadanhada-Bikin terrane; B, Yanji-Khanka–South Primorye Terrane. 4. Palaeotethyan Ocean or palaeooceanic residual pieces. 5. Ancient seamounts. 6. Palaeolatitudes of different strata.

the Yanji-Khanka–South Primorye terrane, not only are there faunas with the Gondwana-Tethys features in the Early Permian, also *Glossopteris* have been found by Zimina (1967) and Huang (in Tang et al. 1992) which do not exist elsewhere in North-east Asia and are neglected by many researchers. In addition, in the South Primorye area *Timorites* and *Cyclolobus* have been found, which are also found in north Tibet, Kashmir and Timor island. The warm type 'Tianqiaoling flora' ($T_{3t}$) is found in the Yanbian area (Sun 1981), but the cool type 'Dajianggang flora' ($T_{3d}$) exists in the central and southern parts of Jilin Province, which attaches to the Yanbian area through the Dun-Mi fault. Previous palaeomagnetic data show a sequence of the terrane locations as: $P_1$—3.3°S, $T_3$—22.9°N, $J_1$—29.4°N (Liu 1994), $K_1$—41°N and N—46.5°N (Bretstein 1988), the Neogene palaeolatitude approaching the present latitude.

Much has been done by palaeontologists on the Permian palaeogeography of Inner Mongolia. Some palaeontologists suggested that Inner Mongolia–Yanbian–Japan belong to the same seaway during the Permian, called 'Sino-Mongolian Seaway' (Shi & Zhan 1996) or the 'Inner Mongolian–Japanese Transition Zone' (Tazawa 1991). Some tectonists (Li & Wang 1983) concluded that the suture line of the Siberian and North-China plates went across central Inner Mongolia, passing through the Xar Moron River and the collision took place before the Late Permian. One of their reasons is that there are different bioclimatic zones on each side of the river in the Early Permian (Huang 1983). We believe that the collision of the two plates occurred in the Late Devonian–Early Carboniferous; during the Permian this area was already an epicontinental sea (Shao 1991). The phenomenon of the mixed warm-water and cool-water faunas exists actually on both sides of the Xar Moron River (Table 3).

| North of Xar Moron River | | South of Xar Moron River |
|---|---|---|
| Jisu Formation | Huanggangliang Formation | Yujiabeigou Formation |
| *Spiriferella, Yakovlevia, Liosotella, Horridonia, Kochiproductus, Gypospirifer, Schwagerina, Pseudodoliolina, Parafusulina, Codonofusiella, Waagenophyllum, Enteletes, Wentzelella, Richthofenia* | *Cyathocarinia, Bradyphyllum, Metriophyllum, Neospirifer, Spiriferella, Yakovlevia, Kochiproductus, Liosotella, Anidanthus, Waagenoconcha, Pseudodoliolina, Leptodus nobilis* | *Pseudodoliolina, Schwagerina, Compresoproductus, Leptodus, Uncinunellina, Waagenoconcha, Yakovlevia mammatiformis* |
| Hugete Formation | Dashizhai Formation | |
| *Monodiexodina, Liosotella, Waagenoconcha, Yakovlevia, Anidanthus, Paramarginifera, Parafusulina, Richthofenia* | *Timorphyllum, Paracaninia, Paeckelmanella, Waagenoconcha, Anidanthus, Compressoproductus, Transennatia, Spinomarginifera* | |
| | Qingfengshan Formation | Sanmianjing Formation |
| | *Paeckelmanella, Waagenoconcha, Avicolopencten* | *Misellina, Nankinella, Parafusulina, Yatsengia, Szechuanophyllum, Orthotichia, Neoplicatifera, Monodiexodina, Cyathocarinia, Metriophyllum, Timorphyllum, Endamplexus* |

*Table 3.* Correlation of Lower Permian faunas in Central Inner Mongolia.

We believe that the minor difference in the biological associations of both sides is caused by submarine rifts and rises. Existence of the Permian continental rift belts can be demonstrated with the bimodal volcanic and alkaline granites (Shao 1991; Hong et al. 1991; Tang et al. 1992).

The Inner Mongolian epicontinental sea and the Yanbian–Sikhote area may not be connected during the Permian because the mixed fossils in Inner Mongolia differ from those in the Yanji area and south Primorye. Besides the basal conglomerate of Dashizhai Formation ($P_{1d}$) containing large amount of granite-gravel is found in the Suolun area west of the Nenjiang fault. This fact indicates that the present Song-Liao basin was a S–N stretching rise during the Permian. In addition, Permian palaeomagnetic data show that Sikhote-Alin and Inner Mongolia were separated.

## CONCLUSIONS

1. The Yanji–South Primorey terrane and the Nadanhata terrane are transported from the low latitude Tethys Ocean.
2. In the Early Permian, Inner Mongolia was only an epicontinental sea with some Tethys-type fauna, and it has nothing to do with the Tethys Ocean.
3. We should distinguish an epicontinental sea with Tethyan biota elements from the real Tethys Ocean. Thus, we should be careful in using the term of Tethys to a particular situation like North-east Asia.

## ACKNOWLEDGEMENTS

This work is supported by the Natural Science Foundation of China.

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